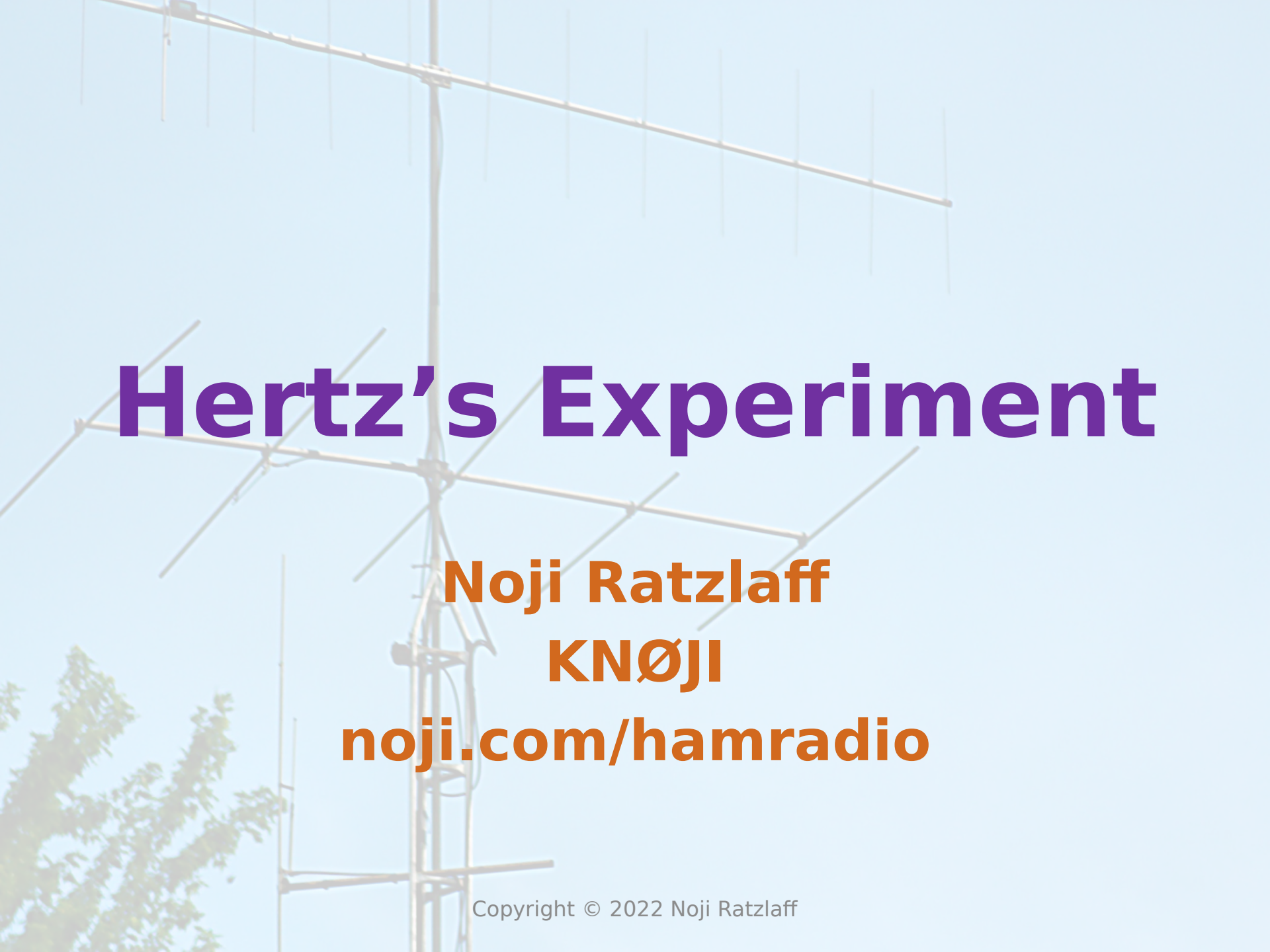


Hertz's Experiment

Noji Ratzlaff

KNØJI

noji.com/hamradio

First, a quick history lesson

Karl Gauss, 1813

- **Electric field, magnetic field**

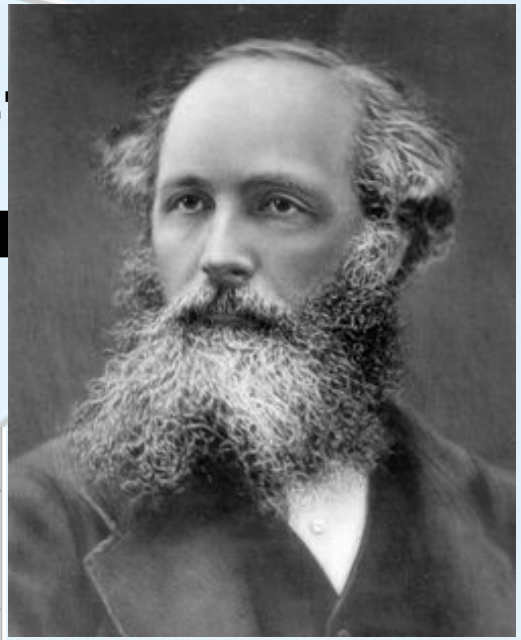
Andre Ampere, 1825

- **Magnetic energy**

Michael Faraday, 1838

- **Magnetic induction**

James Maxwell



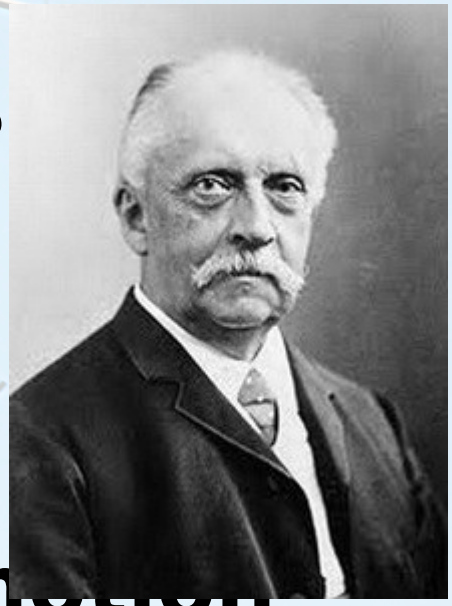
In 1861, he put it all toge

- **Light and magnetic ener**

Maxwell's equations

Integral equations	Differential equations
$\oiint_{\partial\Omega} \mathbf{E}\cdot\mathrm{d}\mathbf{S} = \frac{1}{\varepsilon_0}\iiint_{\Omega}\rho\,\mathrm{d}V$	$\nabla\cdot\mathbf{E} = \frac{\rho}{\varepsilon_0}$
$\oiint_{\partial\Omega} \mathbf{B}\cdot\mathrm{d}\mathbf{S} = 0$	$\nabla\cdot\mathbf{B} = 0$
$\oint_{\partial\Sigma} \mathbf{E}\cdot\mathrm{d}\boldsymbol{\ell} = -\frac{\mathrm{d}}{\mathrm{d}t}\iint_{\Sigma}\mathbf{B}\cdot\mathrm{d}\mathbf{S}$	$\nabla\times\mathbf{E} = -\frac{\partial\mathbf{B}}{\partial t}$
$\oint_{\partial\Sigma} \mathbf{B}\cdot\mathrm{d}\boldsymbol{\ell} = \mu_0\left(\iint_{\Sigma}\mathbf{J}\cdot\mathrm{d}\mathbf{S} + \varepsilon_0\frac{\mathrm{d}}{\mathrm{d}t}\iint_{\Sigma}\mathbf{E}\cdot\mathrm{d}\mathbf{S}\right)$	$\nabla\times\mathbf{B} = \mu_0\left(\mathbf{J} + \varepsilon_0\frac{\partial\mathbf{E}}{\partial t}\right)$

Hermann von Helmholtz



Brilliant scientist / profess

- **Conservation of energy**
- **Fluid dynamics**

Obsessed with optics

- **How we perceive color, motion**

Sought a PhD student to help prove Maxwell

Encountered Heinrich Hertz

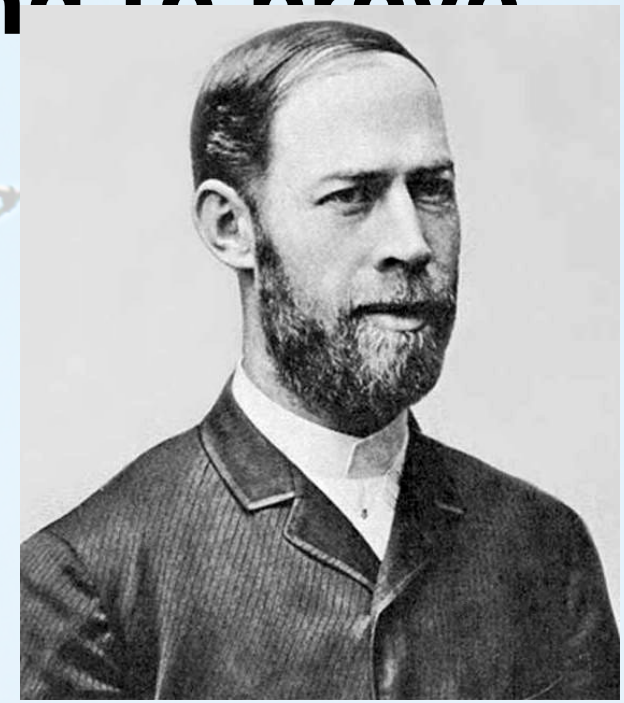
Heinrich Hertz

PhD student at University of Berlin, 1886

Tinkering around, trying to prove Maxwell right

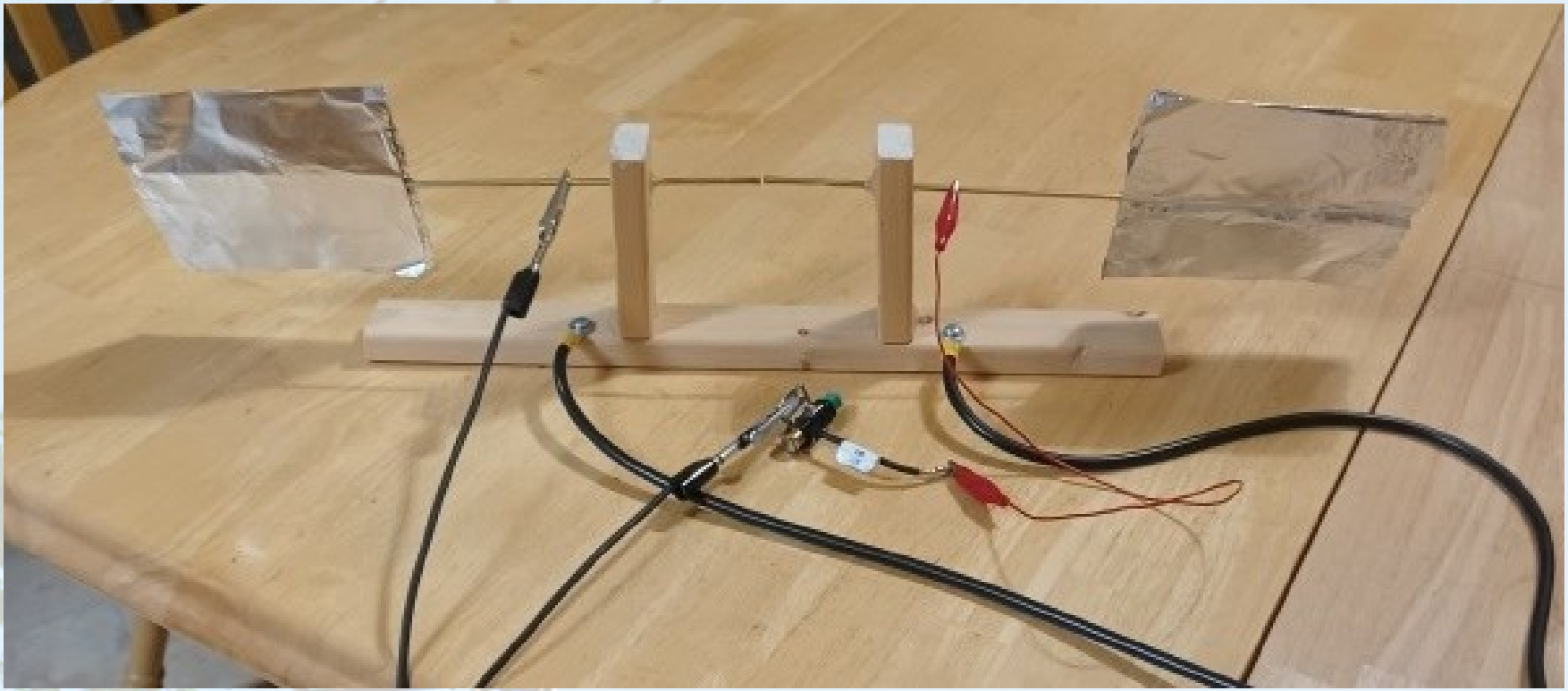
Discharged a Leyden jar into a coil, and a spark appeared across the room

This was the first evidence that Maxwell was correct



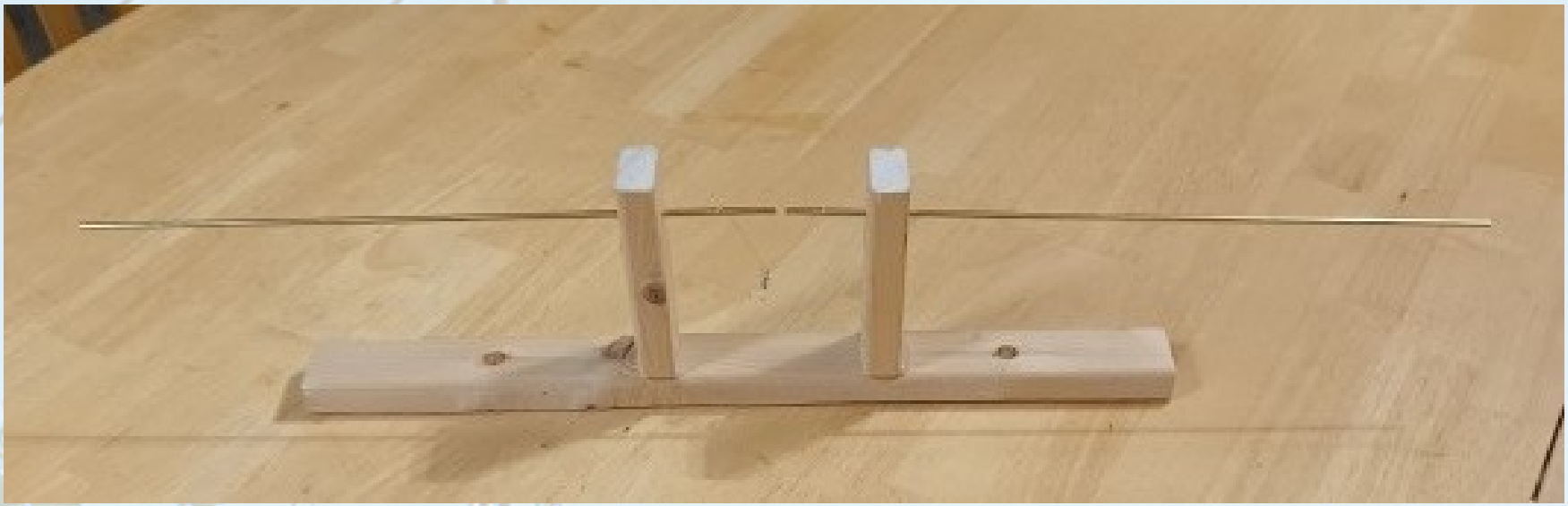
Our one-shot transmitter

A piezoelectric igniter, a capacitor, a spark gap, an “antenna” of

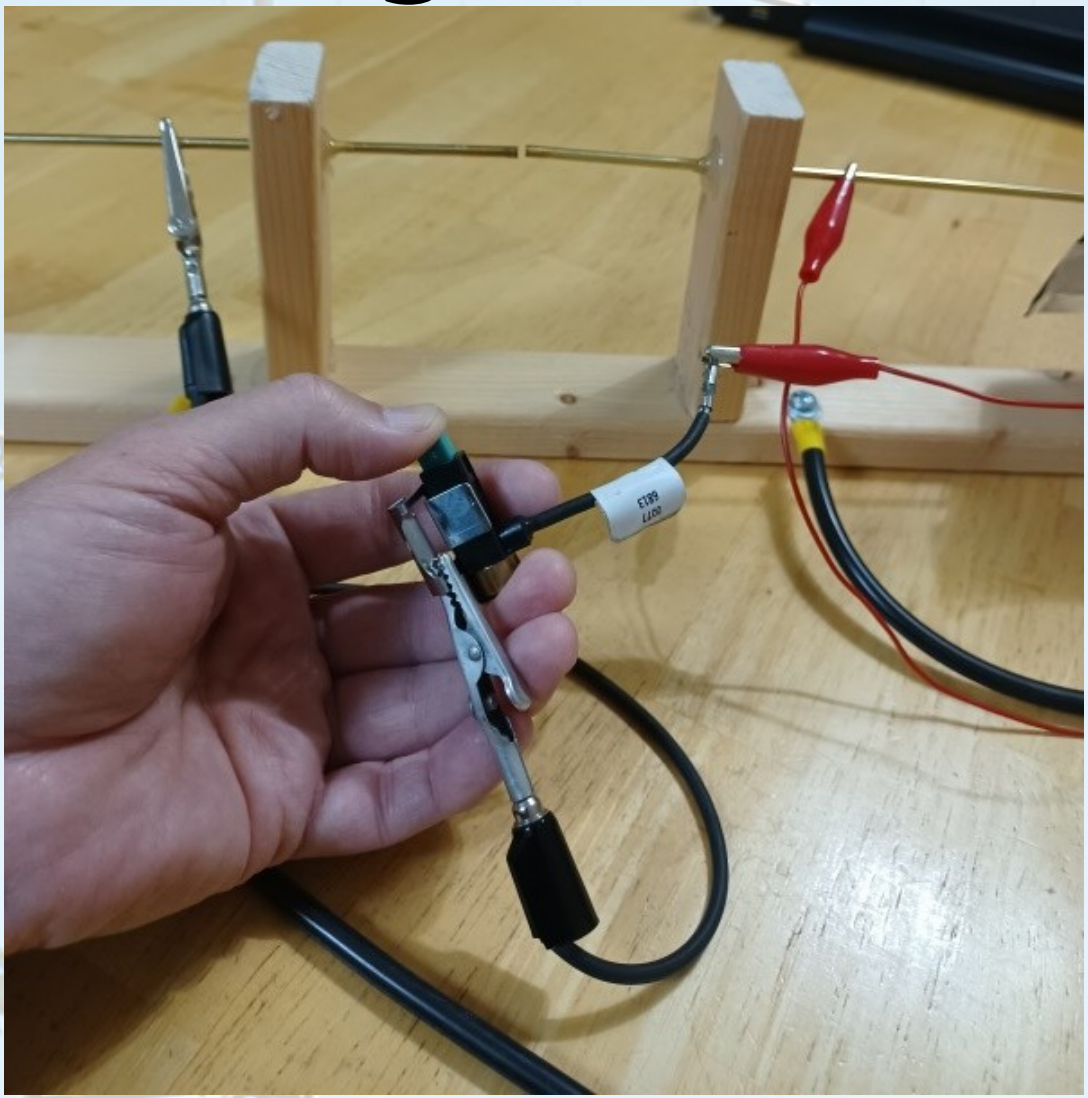


Our receiver

A dipole antenna and a neon bulb

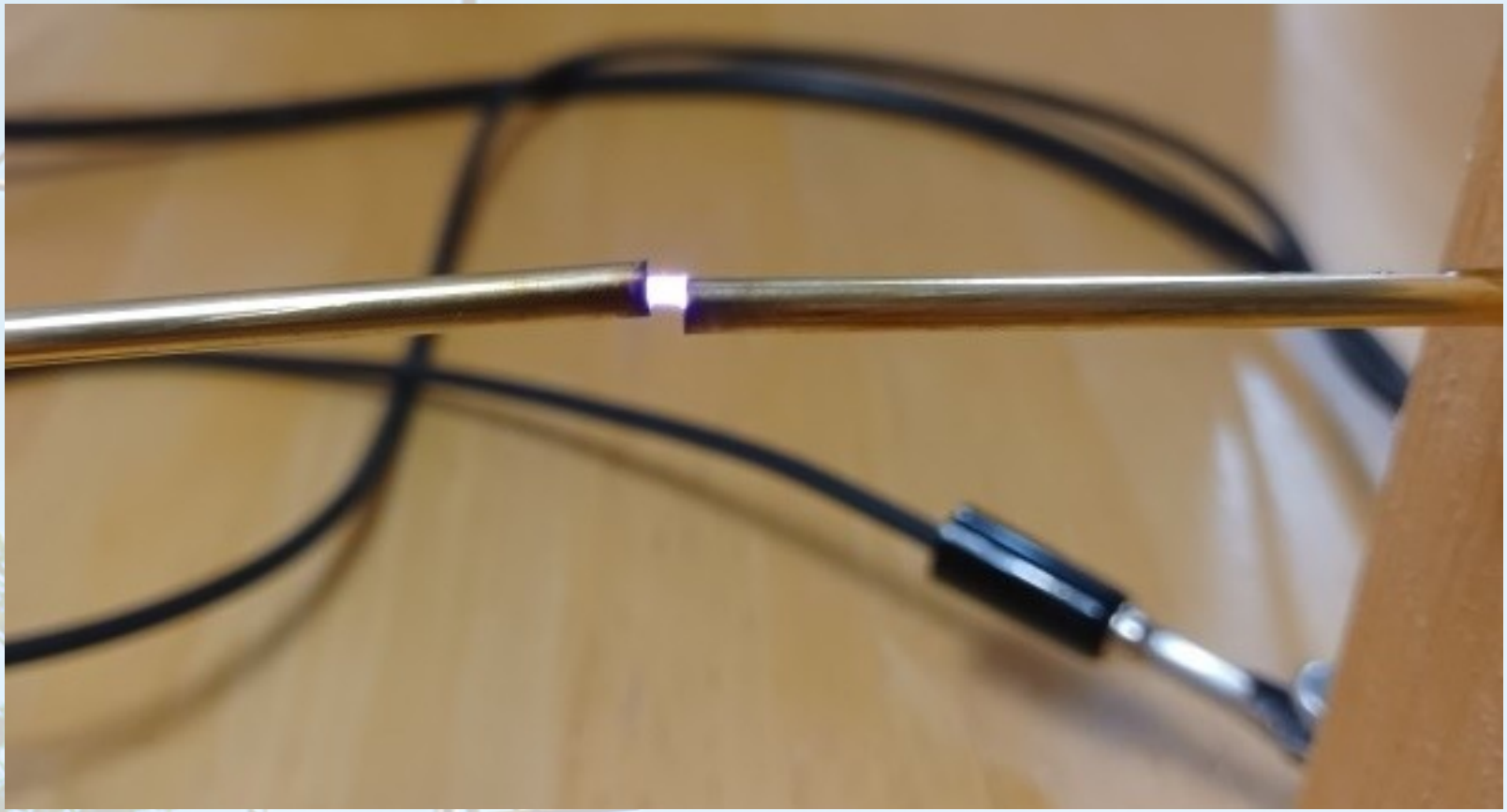


Pushing the button



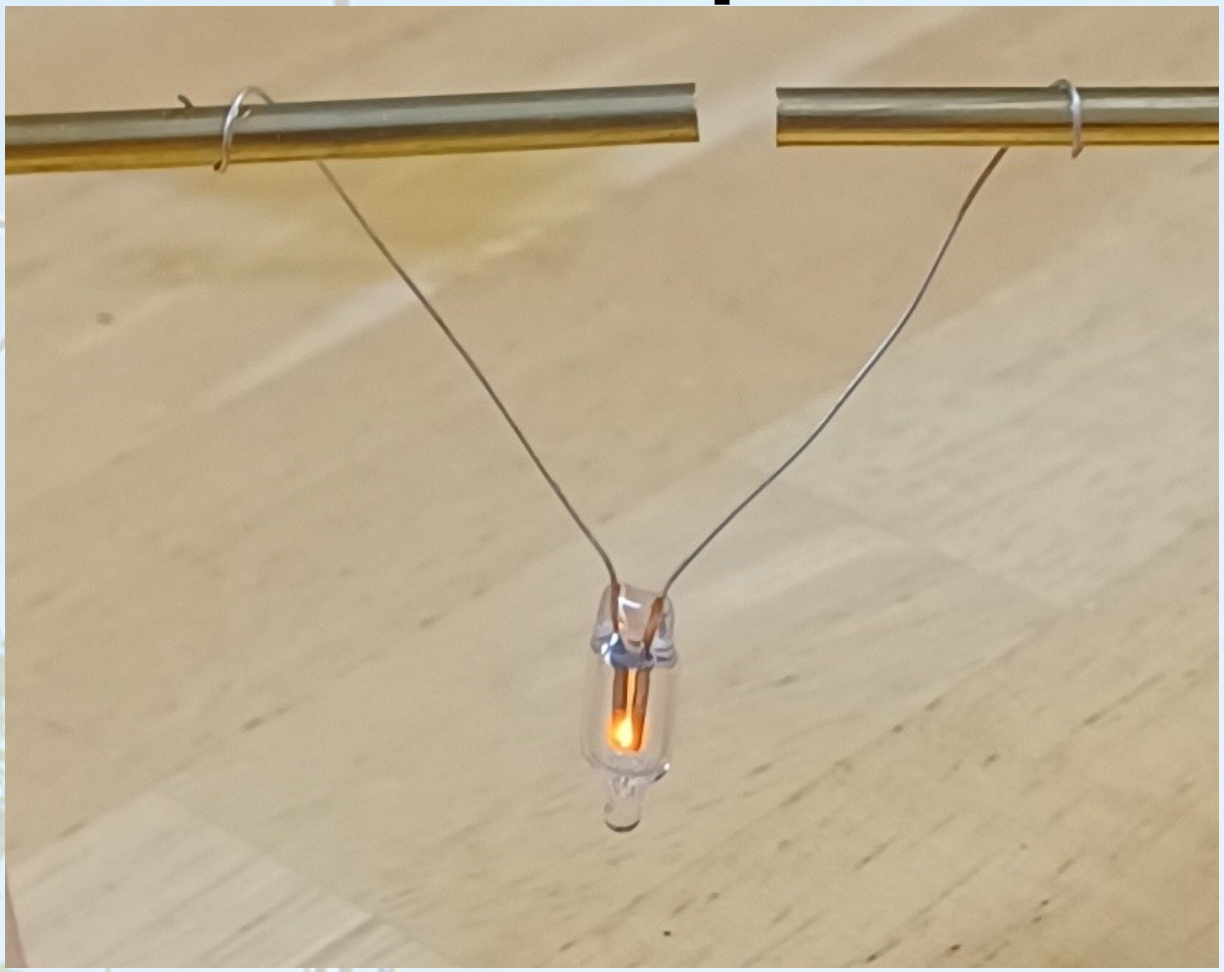
Spark gap needs to spark

Excites the oscillation current



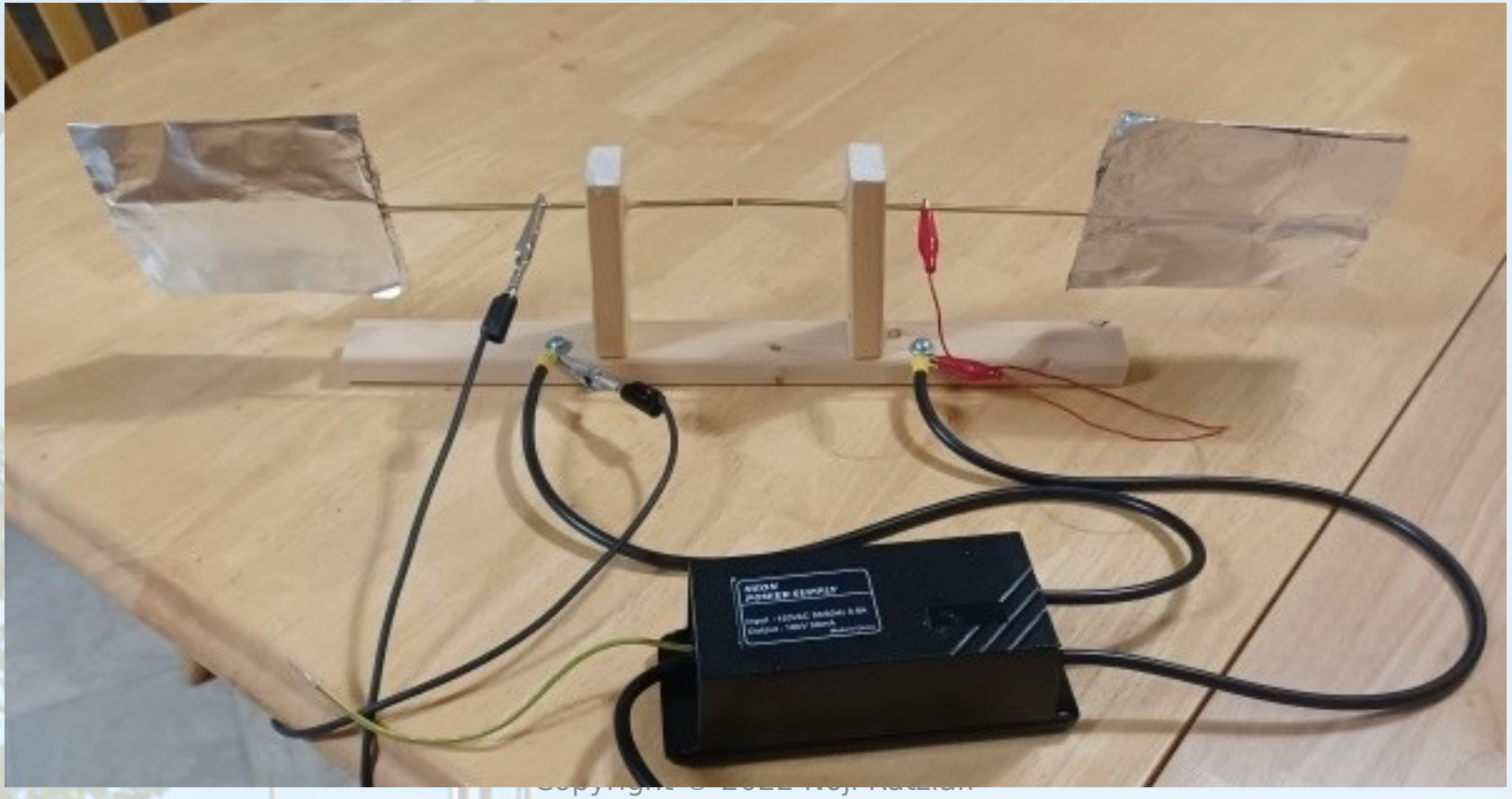
Wireless signal received

The neon bulb lit up momentarily



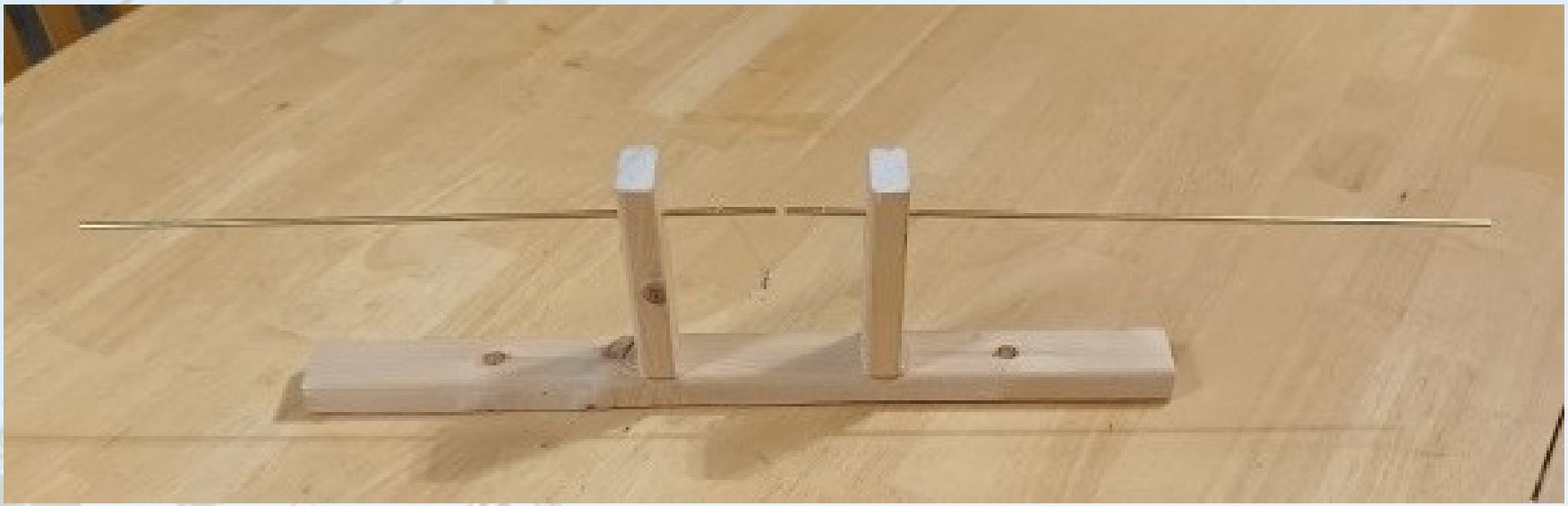
Now try a continuous transmitter

A high-voltage DC source, a capacitor, a spark gap, an



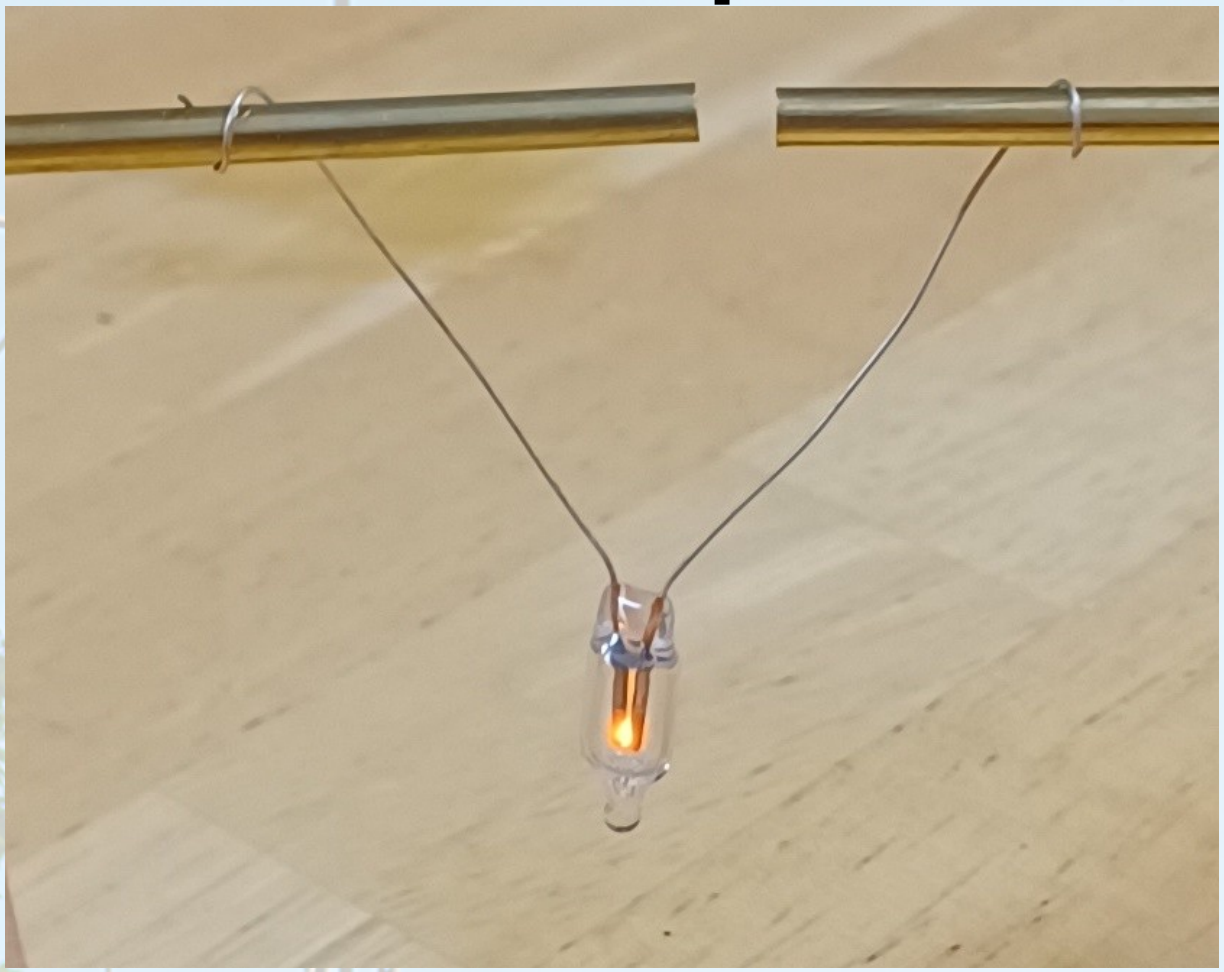
Same receiver

A dipole antenna and a neon bulb



Wireless signal received

The neon bulb lit up continuously



Hertz's conclusions

- Electrical energy can be ***sent through the air***
- Maxwell was correct: electrical energy and magnetic energy unavoidably interact, called today ***electromagnetic radiation***
- Maxwell was correct: ***light*** is another form of electromagnetic radiation
- Maxwell was correct: because the radiation has frequency, it travels in ***waves***
- These newly discovered waves are ***useless***
- He got his PhD anyway

Hertz's useless implications

- Radio
- TV
- WiFi
- Cell phones
- Radar
- Satellite communication
- Body medical scans
- GPS and navigation
- Drones, RC craft, toys
- Radiation therapy
- Microwave ovens
- X-rays
- Others?

Don’t try this at home

- **The high voltage can injure children**
- **The radio waves are often outside amateur band limits if the signal is strong enough**
- **But if you must attempt this experiment, here’s a YouTube link to help you:**

https://youtu.be/9gDFll6Ge7g

Q & A

- **Where does electromagnetic radiation originate?**
- **How far do radio waves travel?**